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Recent Estimates of Reproductive Rates For Harp Seals in the Northwest Atlantic

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Abstract

The pregnancy rate and mean age of sexual maturity of harp seals (*Phoca groenlandicus*) are two important reproductive parameters with respect to the management of this species in the Northwest Atlantic. They may be useful indices of population change, and in addition, pregnancy rate data are incorporated into the current harp seal population model. This research document provides new data on these parameters and describes our general reproductive sampling protocol. Estimates of the total number of harp seals in the Northwest Atlantic declined from approximately 3.0 million in the 1950s to 1.8 million in the early 1970s and then increased steadily to 5.2 million in 1998. During this period, overall pregnancy rates increased from approximately 85% in the 1950s to a high of 95.7% in the mid 1960s and then declined steadily to approximately 64.3% by the mid 1980s and early and 1990s. Pregnancy rates for the period from 1995-1997 have increased to 70.6%. Concurrently, the mean age of sexual maturity decreased from 5.8 years in the mid 1950s to 4.6 in the early 1980s and then increased to 5.6 years of age by the late 1990s. Given the population dynamics of the harp seals, these changes in pregnancy rates and mean age of sexual maturity are consistent with a density dependent response. However, coinciding with the increase in seal abundance in recent years there have also been significant changes in oceanographic conditions in the Northwest Atlantic that may have influenced the availability of prey species.

Résumé

Le taux de grossesse et l'âge moyen de maturité sexuelle des phoques du Groenland (*Phoca groenlandicus*) sont deux paramètres de reproduction importants pour la gestion de cette espèce dans l'Atlantique nord-ouest. Ils peuvent être considérés comme des indices utiles des fluctuations de la population; d'ailleurs, les données de taux de grossesse sont intégrées au modèle actuel de population de phoques du Groenland. Le présent document de recherche présente de nouvelles données sur ces paramètres et décrit notre protocole général d'échantillonnage lié à la reproduction. Le nombre total estimé de phoques du Groenland dans l'Atlantique nord-ouest est passé d'environ 3,0 millions dans les années 1950 à 1,8 millions au début des années 1970, puis a graduellement augmenté jusqu'à 5,2 millions en 1998. D'environ 85 % dans les années 1950, les taux de grossesse globaux ont atteint un maximum de 95,7 % au milieu des années 1960, puis ont graduellement diminué à environ 64,3 % dans le milieu des années 1980 et au début des années 1990, avant de remonter à 70,6 % dans la période allant de 1995 à 1997. L'âge moyen de maturité sexuelle, qui était de 5,8 ans au milieu des années 1950, a baissé à 4,6 ans au début des années 1980, puis a augmenté à 5,6 ans à la fin des années 1990. Étant donné la dynamique de la population de phoques du Groenland, ces fluctuations du taux de grossesse et de l'âge moyen de maturité sexuelle sont en accord avec une dépendance de la population à la densité. Toutefois, des changements importants des conditions océaniques de l'Atlantique nord-ouest ont coïncidé avec l'augmentation de la population de phoques depuis quelques années et pourraient avoir influé sur la disponibilité des espèces dont se nourrissent les phoques du Groenland.

Introduction

Significant changes in the population size of many animal species are often accompanied by changes in reproductive parameters. Two of these parameters, pregnancy rate and mean age of maturity, are of particular interest with respect to the management of Northwest Atlantic harp seals because they may be convenient indices of population change.

Although the accuracy of the various population estimates made for the Northwest Atlantic harp seals may be argued, it is generally believed that the numbers declined during the commercial seal hunt from approximately 3 million in 1952 to 1.5 million in the early 1970s. Following the imposition of a quota in 1971, the population increased throughout the 1970s and early 1980s. The demise of the large vessel hunt in 1983 further reduced catches; by 1994 the population had increased to an estimated 4.8 million seals (Sergeant 1991; Stenson et al. 1993; Shelton et al. 1996; Warren et al. 1997). Model projections using the 1994 pup production information estimated the total population to be approximately 5.3 million in 1998 (Stenson et al. 1999).

Biological sampling of female reproductive tracts began in 1951 and has continued to the present. Mean age of maturity declined from 5.8 years in early 1950s to a low of 4.6 in the early 1980s and then gradually increased to 5.4 during the early 1990s. During the same period pregnancy rates increased from 86.3% in the early 1950s to 95.7% in the mid 1960s and then steadily declined to a low of 69.0% by the early 1990s (Bowen et al. 1981; Sjare and Stenson 1996). Given that both parameters changed concurrently with the decline in population numbers, density dependent mechanisms are likely important. This working paper provides an overview of our current reproductive sampling protocol and presents new data on pregnancy rates and mean age of sexual maturity from 1995 – 1997.

Materials and Methods

Since 1980, female reproductive tracts and jaws have been collected from harp seals in most regions of Newfoundland and southern Labrador during all times of the year except summer. The most consistently sampled area is the northeast coast of Newfoundland between November and May. Historic data were obtained from Bowen et al. (1981) and are based on samples collected primarily in northeast Newfoundland during the spring (late March-April) or winter (January-February).

We have summarized information on female harp seal reproductive parameters annually from 1954 to 1997. In order to obtain larger sample sizes and to smooth some of the annual variability this information has also been combined into six periods, 1951-1954, 1964-1970, 1978-1982, 1985-1989, 1990-1994 and 1995-1997. The first period represents the historic population high, the

second, the decline during the commercial hunt, the third and fourth, the increase in numbers after the imposition of a quota and demise of the large vessel hunt, and the final two, the recent population high. Although the period designations reflect the long-term population trajectory and the availability of data, they are descriptive. A more objective representation of age specific pregnancy rates using sequential 2x2 contingency table tests has also been presented using the following protocol. The initial table compared the proportion of females pregnant or non-pregnant in an age class in two successive years. The chi square statistic (1 d.f.) was calculated and if the null hypothesis of common pregnancy rate was accepted these data were pooled and a new 2x2 table was formed by including the next year's data. This procedure was continued as long as the successive chi square values remained non-significant. When a significant value was encountered, the sequence was terminated and a new sequence begun starting with the year for which a significant change in pregnancy rate was indicted.

Age was determined to the nearest year by counting dentine annuli. The reproductive condition of females was assessed by sectioning and examining the ovaries. The overall pregnancy rate is defined as the percentage of mature females pregnant at the time of the samples. Age specific pregnancy rates are presented as the percentage of females pregnant in a particular age class regardless of maturity status. Because of delayed implantation, pregnancy rate is easily measured only in fall and winter samples; we used samples collected between September and February (i.e. late term pregnancy rate). Mean age of sexual maturity (MAM) was defined as the age of first ovulation and calculated using the algorithm of Demaster (1978, 1984) from samples obtained throughout the season, excluding March. Possible differences between sampling periods were tested using t-tests. To obtain mean age of first reproduction (whelping), one year must be added to the ages reported here.

Results and Discussion

The overall pregnancy rate has varied considerably during the six study periods. The rate was 86.3% when the population was at a high level during the mid 1950s, it increased to 95.7% during the commercial hunt period in the mid 1960s and then steadily declined to a low of 64.3% by the early 1990s. During the period from 1995-1997 pregnancy rates have increased to 70.6% (Table 1); in 1997 the rate was 76.2%(32/42).

Annual harp seal reproductive samples are presented in Table 2 and annual, late term age specific pregnancy rates for all females aged 3 to 7+ are shown in Table 3. There was considerable inconsistency in these data due to missing information and small sample sizes in some years. However, rates appeared to drop notably in 1987 and the trend has continued for most age classes. Age specific pregnancy rates based on blocked periods for all females in each age class are presented in Figure 1 and Table 4. For 3 and 4 year old seals

the proportion pregnant was low in the mid 1950s, increased until the early 1980s, and then started to decline into the early 1990s and has remained low. Seals aged 5 and 6 years exhibited a similar, but less notable trend. The pregnancy rate of 7+ year old seals has declined particularly in the mid 1980s and early 1990s. Results of the age specific sequential contingency table tests showed the same general trends (Table 5). The MAM decreased from 5.8 years in the mid 1950s to a low of 4.6 years in the early 1980s, then increased to 5.2 in the early 1990s and was 5.6 from 1995-1997 (Table 6). The MAM for the mid 1950s and mid 1990s were significantly higher than during the early 1980s.

Although the relationship between pregnancy rate, age at maturity and recent changes in the size of the Northwest Atlantic harp seal population has not be examined in detail, results suggest that both these reproductive parameters have behaved in a manner which is consistent with a density dependent response. However, the mechanisms responsible for changes in these parameters are not known. Chabot et al. (1996) noted that from 1990 -1994 growth rates for young females (< 5 years old) taken in Newfoundland waters were significantly slower than at any other period of time since 1976. The same study also showed that young males weighed less and were shorter at a given age in 1990 -1994. Older seals of both sexes were in worse post breeding condition in 1992 that in the mid 1980s, but they did not differ from seals sampled in 1981 or 1979. More recently (1995 to present), there have numerous reports from Newfoundland and Labrador fishermen that suggest juvenile harp seals from some areas of the Province are in poor condition (i.e. decreased blubber layer). Similarly, the body condition of harp seals sampled in the Gulf of St. Lawrence, Quebec also declined between 1988 and 1992 (Hammill pers. comm.). Given that resources for an adequate biological sampling program have always been limited it is difficult to evaluate if these findings represent a short-term or limited geographical phenomenon or whether there are more prolonged, larger scale trends. However, growth and body condition are likely coupled with foraging efficiency, prey availability and prey quality and all of these factors may have changed significantly due to the wide spread environmental perturbations in the Northwest Atlantic in recent years.

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Table 1: Summary of overall pregnancy rates (number pregnant/total number of mature females).

Block Periods	N	Proportion Pregnant
1951-54	44/51	0.8627
1965-70	738/771	0.9572
1978-82	153/171	0.8947
1985-89	93/128	0.7267
1990-94	135/210	0.6429
1995-97	83/119	0.6975

Table 2: Sampling of late-term pregnancy rates, where p is the number of pregnant animals and n is the sample size.

Year	Age									
	3		4		5		6		7+	
	p	n	p	n	p	n	p	n	p	n
1954	0	4	1	3	2	3	12	16	29	33
1965	1	30	5	44	20	37	27	38	96	109
1966	0	7	1	9	6	17	8	11	43	49
1967	0	10	4	19	20	33	28	29	109	123
1968	0	27	6	19	14	20	11	12	48	55
1969	1	25	4	25	7	16	23	28	123	164
1970	0	13	3	13	6	12	9	10	92	107
1978	1	40	23	38	18	20	6	9	35	41
1979	3	9	5	9	3	3	3	4	10	11
1980	0	2	1	2	1	1		0	10	12
1981	1	5	2	4	1	2	6	7	14	18
1982	0	4	2	5	1	1	3	4	1	3
1985	0	4	1	3	2	5	3	3	1	1
1986	1	1		0	1	2	0	1	7	7
1987	2	12	3	8	7	9	4	4	15	24
1988	2	17	1	6	3	3		0	14	19
1989	0	8	0	9	2	6	2	3	21	22
1990	0	3	1	7	1	3	0	2	6	10
1991	1	11	2	11	4	7	1	3	18	29
1992	2	10	3	11	4	9	6	8	21	32
1993	0	11	2	17	0	7	4	5	16	35
1994	1	23	2	16	6	14	3	7	34	41
1995	1	11	6	13	2	4	2	5	14	24
1996	0	8	0	6	1	4	1	1	24	35
1997	0	6	0	4	3	10	2	2	27	35

Table 3: Annual, late-term age-specific pregnancy rates for females aged 3 to 7+.

Year	3	4	5	6	7+
1954	0.0000	0.3333	0.6667	0.7500	0.8788
1965	0.0333	0.1136	0.5405	0.7105	0.8807
1966	0.0000	0.1111	0.3529	0.7273	0.8776
1967	0.0000	0.2105	0.6061	0.9655	0.8862
1968	0.0000	0.3158	0.7000	0.9167	0.8727
1969	0.0400	0.1600	0.4375	0.8214	0.7500
1970	0.0000	0.2308	0.5000	0.9000	0.8598
1978	0.0250	0.6053	0.9000	0.6667	0.8537
1979	0.3333	0.5556	1.0000	0.7500	0.9091
1980	0.0000	0.5000	1.0000	--	0.8333
1981	0.2000	0.5000	0.5000	0.8571	0.7778
1982	0.0000	0.4000	1.0000	0.7500	0.3333
1985	0.0000	0.3333	0.4000	1.0000	1.0000
1986	1.0000	--	0.5000	0.0000	1.0000
1987	0.1667	0.3750	0.7778	1.0000	0.6250
1988	0.1176	0.1667	1.0000	--	0.7368
1989	0.0000	0.0000	0.3333	0.6667	0.9545
1990	0.0000	0.1429	0.3333	0.0000	0.6000
1991	0.0909	0.1818	0.5714	0.3333	0.6207
1992	0.2000	0.2727	0.4444	0.7500	0.6563
1993	0.0000	0.1176	0.0000	0.8000	0.4571
1994	0.0435	0.1250	0.4286	0.4286	0.8293
1995	0.0909	0.4615	0.5000	0.4000	0.5833
1996	0.0000	0.0000	0.2500	1.0000	0.6857
1997	0.0000	0.0000	0.3000	1.0000	0.7714

Table 4: Estimates of late-term, age-specific pregnancy rates (proportion pregnant) for all female harp seals aged 3 to 7+ years based on blocked periods.

Block Periods	Age				
	3	4	5	6	7+
1951-54	0.0000	0.3333	0.6667	0.7500	0.8788
1965-70	0.0982	0.1783	0.5407	0.8281	0.8418
1978-82	0.0833	0.5690	0.8889	0.7500	0.8235
1985-89	0.1190	0.1923	0.6000	0.8182	0.7945
1990-94	0.0690	0.1613	0.3750	0.5600	0.6463
1995-97	0.0400	0.2609	0.3333	0.6250	0.6915

Table 5: Late-term, age-specific pregnancy rates based on sequential contingency tables tests.

Age	Time Periods	Pregnancy Rates
Age 3	1954-78	0.0192
	1979-92	0.1395
	1993-96	0.0377
Age 4	1954-70	0.1818
	1978-81	0.5849
	1982-96	0.2054
Age 5	1954-70	0.5435
	1978-82	0.8889
	1985-92	0.5455
	1993-96	0.3103
Age 6	1954-66	0.7231
	1967-68	0.9512
	1969-87	0.8143
	1989-96	0.5588
Age 7+	1954-81	0.8740
	1982-89	0.7763
	1990-96	0.6456

Table 6: Mean age of sexual maturity (MAM).

Year	MAM	Variance	95% C.I. Lower	95% C.I. Upper
1951-1954	5.8	0.006	5.3	6.3
1964-1970	5.3	0.005	5.2	5.4
1978-1982	4.6	0.005	4.5	4.7
1985-1989	4.9	0.035	4.5	5.3
1990-1994	5.2	0.020	4.9	5.5
1995-1997	5.6	0.016	5.3	5.9

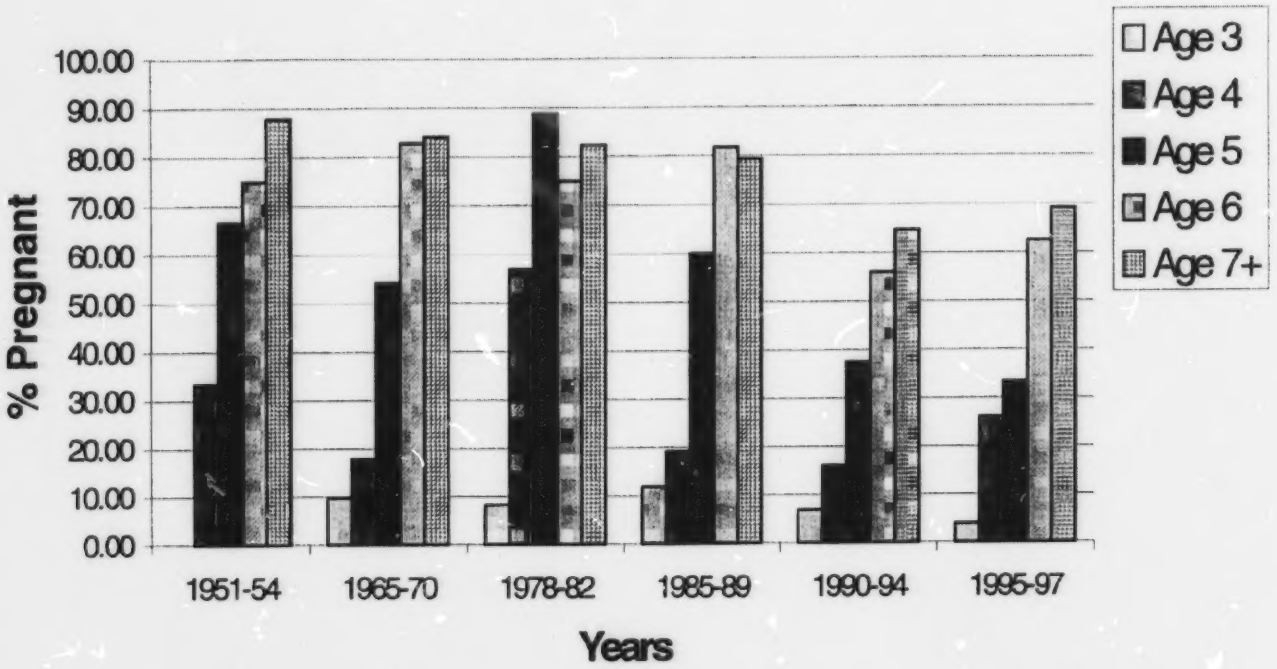

Figure 1: Age-specific pregnancy rates based on mature and immature female harp seals.